

WHAT IS CLAIMED IS:

1. An optical signal processing device comprising:  
an optical path superposing and separating unit for receiving two signal  
lights, superposing once optical paths of the two inputted signal lights with each  
other, and then separating the two signal lights to be outputted separately, the  
optical path superposing and separating unit including a non-linear waveguide  
arranged in an area where both the optical paths are superposed with each other,  
the non-linear waveguide having a refractive index changed depending on  
externally applied excitation;
- 10                   a first optical waveguide having a signal light input end and an output end  
connected to the optical path superposing and separating unit, the first optical  
waveguide introducing the signal light to the optical path superposing and  
separating unit;
- 15                   a second optical waveguide having a signal light input end and an output  
end connected to the optical path superposing and separating unit, the second  
optical waveguide introducing the signal light to the optical path superposing and  
separating unit, the second optical waveguide having an optical path length from  
the input end thereof to the optical path superposing and separating unit, which is  
longer than an optical path length of the first optical waveguide from the input end  
thereof to the optical path superposing and separating unit;
- 20                   a control-light introducing optical system for introducing a control light to the  
non-linear waveguide;
- 25                   an interference separator for receiving the two signal lights and distributing  
the inputted signal lights depending on a phase difference between the two signal  
lights;

a third optical waveguide for connecting the optical path superposing and separating unit to the interference separator, and introducing one of the signal lights outputted from the optical path superposing and separating unit to the interference separator; and

5 a fourth optical waveguide for connecting the optical path superposing and separating unit to the interference separator, and introducing the other signal light outputted from the optical path superposing and separating unit to the interference separator, the fourth optical waveguide having a shorter optical path length than the third optical waveguide, the optical path length of the fourth optical waveguide  
10 being set such that a delay time of the signal light propagating through the second optical waveguide relative to the signal light propagating through the first optical waveguide is canceled at time when the two signal lights reach the interference separator.

15 2. An optical signal processing device according to Claim 1, wherein the control-light introducing optical system includes a control-light inputting waveguide merging with one of the first optical waveguide and the second optical waveguide.

20 3. An optical signal processing device according to Claim 1, wherein a first phase adjuster for delaying a light propagating therethrough and adjusting a delay amount in accordance with an externally applied control signal is inserted in at least one of the first optical waveguide and the second optical waveguide.

25 4. An optical signal processing device according to Claim 1, wherein a first phase adjuster for delaying a light propagating therethrough and adjusting a delay amount in accordance with an externally applied control signal is inserted in at

least one of the third optical waveguide and the fourth optical waveguide.

5. An optical signal processing device according to Claim 1, wherein the optical path superposing and separating unit includes a semiconductor optical amplifier having a plane waveguide, and optical paths of the two signal lights inputted to the semiconductor optical amplifier are selected such that the two optical paths cross each other in the plane waveguide in an orthogonal relation.

6. An optical signal processing device according to Claim 1, wherein the 10 optical path superposing and separating unit includes a 2-input and 2-output multimode interferometer for outputting the signal light applied through one input point thereof from one output point thereof and outputting the signal light applied through the other input point thereof from the other output point thereof, and the two signal lights applied through the two input points are superposed with each 15 other in the multimode interferometer, the multimode interferometer including a non-linear waveguide arranged in an area where the two signal lights are superposed with each other.

7. An optical signal processing device according to Claim 1, wherein the 20 optical path superposing and separating unit comprises:  
a first multimode interferometer having at least two input points and at least two output points;  
a second multimode interferometer having input points corresponding to the output points of the first multimode interferometer, and at least two output points;  
25 a plurality of waveguides for connecting the output points of the first multimode interferometer to the corresponding input points of the second

multimode interferometer, at least one of the plurality of waveguides being a non-linear waveguide,

wherein the signal light applied through one of the input points of the first multimode interferometer passes the plurality of waveguides and exits from one of the output points of the second multimode interferometer, and the signal light applied through another input point of the first multimode interferometer passes the plurality of waveguides and exits from another output point of the second multimode interferometer.

10 8. An optical signal processing device according to Claim 1, wherein the non-linear waveguide is constituted by a semiconductor optical amplifier.

9. An optical signal processing device according to Claim 1, further comprising a branching multimode interferometer for outputting the signal light applied through an input point thereof from two output points thereof with intensities almost equal to each other, the branching multimode interferometer having one of the output points connected to the input end of the first optical waveguide and the other output point connected to the input end of the second optical waveguide.

20 10. An optical signal processing device according to Claim 1, wherein the control-light introducing optical system includes a combining multimode interferometer inserted midway one of the first optical waveguide and the second optical waveguide, the combining multimode interferometer having at least two input points and one output point, one of the input points and the output point being both connected to the one optical waveguide, the combining multimode

interferometer receiving the control light applied through the other input point thereof and outputting both the signal light applied through the one input point thereof and the control light applied through the other input point thereof from the output point thereof.

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11. An optical signal processing device according to Claim 1, wherein the interference separator includes a 2-input and 2-output separation multimode interferometer having one input point connected to the third optical waveguide and the other input point connected to the fourth optical waveguide, the separation multimode interferometer outputting the signal light from one output point thereof when the signal lights applied through the two input points have the same phase, and outputting the signal light from the other output point when the signal lights applied through the two input points have opposite phases.

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12. A wavelength converting device comprising:

an optical path superposing and separating unit for receiving two continuous lights having a first wavelength, superposing once optical paths of the two inputted continuous lights with each other, and then separating the two signal lights to be outputted separately, the optical path superposing and separating unit including a non-linear waveguide arranged in an area where both the optical paths are superposed with each other, the non-linear waveguide having a refractive index non-linearly changed upon a control light pulse having a second wavelength being introduced;

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a first optical waveguide having a continuous light input end and an output end connected to the optical path superposing and separating unit, the first optical waveguide introducing the continuous light to the optical path superposing and

separating unit;

a second optical waveguide having a continuous light input end and an output end connected to the optical path superposing and separating unit, the second optical waveguide introducing the continuous light to the optical path

## 5. superposing and separating unit;

a control-light introducing optical system for introducing a control light pulse to the non-linear waveguide;

an interference separator for receiving the two continuous lights and outputting the light having the first wavelength only during a period in which a

10 phase difference between the inputted two continuous lights satisfies a certain  
condition;

a third optical waveguide for connecting the optical path superposing and separating unit to the interference separator, and introducing one of the continuous lights outputted from the optical path superposing and separating unit to the

15 interference separator; and

a fourth optical waveguide for connecting the optical path superposing and separating unit to the interference separator, and introducing the other continuous light outputted from the optical path superposing and separating unit to the interference separator, the fourth optical waveguide having a shorter optical path length than the third optical waveguide.

13. A wavelength converting device according to Claim 12, wherein the control-light introducing optical system includes a control-light inputting waveguide merging with one of the first optical waveguide and the second optical waveguide.

optical path superposing and separating unit includes a semiconductor optical amplifier having a plane waveguide, and optical paths of the two signal lights inputted to the semiconductor optical amplifier are selected such that the two optical paths cross each other in the plane waveguide in an orthogonal relation.

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15. A wavelength converting device according to Claim 12, wherein the optical path superposing and separating unit includes a 2-input and 2-output multimode interferometer for outputting the continuous light applied through one input point thereof from one output point thereof and outputting the continuous light applied through the other input point thereof from the other output point thereof, and the two continuous lights applied through the two input points are superposed with each other in the multimode interferometer, the multimode interferometer including a non-linear waveguide arranged in an area where the two continuous lights are superposed with each other.

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16. A wavelength converting device according to Claim 12, wherein the optical path superposing and separating unit comprises:

- 10 a first multimode interferometer having at least two input points and at least two output points;
- 20 a second multimode interferometer having input points corresponding to the output points of the first multimode interferometer, and at least two output points;
- 25 a plurality of waveguides for connecting the output points of the first multimode interferometer to the corresponding input points of the second multimode interferometer, at least one of the plurality of waveguides being a non-linear waveguide,

wherein the continuous light applied through one of the input points of the

first multimode interferometer passes the plurality of waveguides and exits from one of the output points of the second multimode interferometer, and the continuous light applied through another input point of the first multimode interferometer passes the plurality of waveguides and exits from another output point of the second multimode interferometer.

17. A wavelength converting device according to Claim 16, wherein the non-linear waveguide is constituted by a semiconductor optical amplifier.

10 18. A wavelength converting device according to Claim 12, further comprising a branching multimode interferometer for outputting the continuous light applied through an input point thereof from two output points thereof with intensities almost equal to each other, the branching multimode interferometer having one of the output points connected to the input end of the first optical waveguide and the other output point connected to the input end of the second optical waveguide.

19. A wavelength converting device according to Claim 12, wherein the control-light introducing optical system includes a combining multimode interferometer inserted midway one of the first optical waveguide and the second optical waveguide, the combining multimode interferometer having at least two input points and one output point, one of the input points and the output point being both connected to the one optical waveguide, the combining multimode interferometer receiving the control light applied through the other input point thereof and outputting both the signal light applied through the one input point thereof and the control light applied through the other input point thereof from the

output point thereof.

20. A wavelength converting device according to Claim 12, wherein the interference separator includes an at least 2-input and 1-output separation 5 multimode interferometer having one input point connected to the third optical waveguide and another input point connected to the fourth optical waveguide, the separation multimode interferometer outputting the signal light from the output point thereof when the signal lights applied through the two input points have opposite phases.

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21. An optical demultiplexer comprising:  
a plurality of drop devices, each of the drop devices having a control light input port to which a control light is applied, a signal light input port to which a signal light is applied, and a drop signal output port;  
15 a signal waveguide for branching a time-division multiplexed signal light and applying a plurality of branched signal lights respectively to the signal light input ports of the drop devices; and  
a control waveguide for branching one control light and applying a plurality of branched control lights to reach the corresponding drop devices at delays  
20 gradually shifted in units of a certain time,  
each of the drop devices comprising:  
a branching optical element for branching the signal light applied through the signal light input port;  
an optical path superposing and separating unit for receiving two signal 25 lights, superposing once optical paths of the two inputted signal lights with each other, and then separating the two signal lights to be outputted separately, the

optical path superposing and separating unit including a non-linear waveguide arranged in an area where both the optical paths are superposed with each other, the non-linear waveguide having a refractive index changed depending on externally applied excitation;

- 5 a first optical waveguide having a signal light input end, through which one of signal lights branched by the branching optical element is inputted, and an output end connected to the optical path superposing and separating unit;

10 a second optical waveguide having a signal light input end, through which the other signal light branched by the branching optical element is inputted, and an output end connected to the optical path superposing and separating unit, the second optical waveguide having an optical path length from the input end thereof to the optical path superposing and separating unit, which is longer than an optical path length of the first optical waveguide from the input end thereof to the optical path superposing and separating unit;

15 a control-light introducing optical system for introducing a control light, which is applied through the control light input port, to the non-linear waveguide; an interference separator for receiving the two signal lights and outputting the signal light from the drop signal output port only when a phase difference between the inputted two signal lights satisfies a certain specific condition;

20 a third optical waveguide for connecting the optical path superposing and separating unit to the interference separator, and introducing one of the signal lights outputted from the optical path superposing and separating unit to the interference separator; and

25 a fourth optical waveguide for connecting the optical path superposing and separating unit to the interference separator, and introducing the other signal light outputted from the optical path superposing and separating unit to the interference

separator, the fourth optical waveguide having a shorter optical path length than the third optical waveguide, the optical path length of the fourth optical waveguide being set such that a delay time of the signal light propagating through the second optical waveguide relative to the signal light propagating through the first optical  
5 waveguide is canceled at time when the two signal lights reach the interference separator.

22. An optical demultiplexer comprising:
- a number  $N$  ( $N$  is two or larger integer) of drop devices, each of the drop  
10 devices having a control light input port to which a control light is applied, a signal light input port to which a signal light is applied, and a drop signal output port;  
a signal waveguide for applying a signal light, which is time-division multiplexed at multiplicity of  $N$  and has a number  $N$  of channels, to the signal light input port of each of the drop devices; and  
15 a control waveguide for branching one control light into a number  $N$  of control lights and applying an  $i$ -th ( $i$  is an integer not smaller than 1 but not larger than  $N$ ) one of the branched control lights to the control light input port of an  $i$ -th drop device,  
the signal waveguide and the control waveguide delaying one of the control  
20 light and the signal light relative to the other such that the control light applied to the  $i$ -th drop device is in sync with an  $i$ -th channel of the signal light applied to the  $i$ -th drop device,  
each of the drop devices comprising:  
a branching optical element for branching the signal light applied through  
25 the signal light input port;  
an optical path superposing and separating unit for receiving two signal

lights, superposing once optical paths of the two inputted signal lights with each other, and then separating the two signal lights to be outputted separately, the optical path superposing and separating unit including a non-linear waveguide arranged in an area where both the optical paths are superposed with each other,

5. the non-linear waveguide having a refractive index changed depending on externally applied excitation;

a first optical waveguide having a signal light input end, through which one of signal lights branched by the branching optical element is inputted, and an output end connected to the optical path superposing and separating unit;

- 10 a second optical waveguide having a signal light input end, through which the other signal light branched by the branching optical element is inputted, and an output end connected to the optical path superposing and separating unit, the second optical waveguide having an optical path length from the input end thereof to the optical path superposing and separating unit, which is longer than an optical path length of the first optical waveguide from the input end thereof to the optical path superposing and separating unit;

15 a control-light introducing optical system for introducing a control light, which is applied through the control light input port, to the non-linear waveguide;

- 20 an interference separator for receiving the two signal lights and outputting the signal light from the drop signal output port only when a phase difference between the inputted two signal lights satisfies a certain specific condition;

- 25 a third optical waveguide for connecting the optical path superposing and separating unit to the interference separator, and introducing one of the signal lights outputted from the optical path superposing and separating unit to the interference separator; and

a fourth optical waveguide for connecting the optical path superposing and

separating unit to the interference separator, and introducing the other signal light outputted from the optical path superposing and separating unit to the interference separator, the fourth optical waveguide having a shorter optical path length than the third optical waveguide, the optical path length of the fourth optical waveguide

5 being set such that a delay time of the signal light propagating through the second optical waveguide relative to the signal light propagating through the first optical waveguide is canceled at time when the two signal lights reach the interference separator.

10 23. An optical demultiplexer comprising:

a number  $N$  ( $N$  is two or larger integer) of drop devices arranged from a first stage to an  $N$ -th stage, each of the drop devices having a control light input port to which a control light is applied, a signal light input port to which a signal light is applied, a drop signal output port from which the signal light is delivered in sync with inputting of the control light, and a through signal output port from which the signal light is delivered at least during a period in which the signal light is not delivered from the drop signal output port;

a first signal waveguide for applying a time-division multiplexed signal light to the signal light input port of the first-stage drop device;

20 a second signal waveguide for connecting the through signal output port of each drop device to the signal light input port of the drop device in a next stage; and

a control waveguide for branching one control light and applying a plurality of branched control lights to reach the corresponding drop devices at delays

25 gradually shifted in units of a certain time toward a most downstream stage, each of the drop devices comprising:

a branching optical element for branching the signal light applied through the signal light input port;

an optical path superposing and separating unit for receiving two signal lights, superposing once optical paths of the two inputted signal lights with each other, and then separating the two signal lights to be outputted separately, the optical path superposing and separating unit including a non-linear waveguide arranged in an area where both the optical paths are superposed with each other, the non-linear waveguide having a refractive index changed depending on externally applied excitation;

10 a first optical waveguide having a signal light input end, through which one of signal lights branched by the branching optical element is inputted, and an output end connected to the optical path superposing and separating unit;

a second optical waveguide having a signal light input end, through which the other signal light branched by the branching optical element is inputted, and an output end connected to the optical path superposing and separating unit, the second optical waveguide having an optical path length from the input end thereof to the optical path superposing and separating unit, which is longer than an optical path length of the first optical waveguide from the input end thereof to the optical path superposing and separating unit;

20 a control-light introducing optical system for introducing a control light, which is applied through the control light input port, to the non-linear waveguide;

an interference separator for receiving the two signal lights, outputting the signal light from the drop signal output port when a phase difference between the inputted two signal lights satisfies a certain specific condition, and outputting the signal light from the through signal output port when the phase difference between the inputted two signal lights satisfies the certain specific condition;

a third optical waveguide for connecting the optical path superposing and separating unit to the interference separator, and introducing one of the signal lights outputted from the optical path superposing and separating unit to the interference separator; and

5 a fourth optical waveguide for connecting the optical path superposing and separating unit to the interference separator, and introducing the other signal light outputted from the optical path superposing and separating unit to the interference separator, the fourth optical waveguide having a shorter optical path length than the third optical waveguide, the optical path length of the fourth optical waveguide  
10 being set such that a delay time of the signal light propagating through the second optical waveguide relative to the signal light propagating through the first optical waveguide is canceled at time when the two signal lights reach the interference separator.

15 24. An optical demultiplexer according to Claim 23, wherein the signal light is a signal having a number N of time-division multiplexed channels, and

wherein the control waveguide delays the control light inputted to an i-th (i is an integer not smaller than 1 but not larger than N) drop device to be in sync with an i-th channel of the signal light inputted to the i-th drop device.

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25. An optical demultiplexer according to Claim 21, further comprising a transducer for converting the signal light delivered from the drop signal output port of each of the drop devices into an electrical signal.

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26. An optical demultiplexer according to Claim 22, further comprising a transducer for converting the signal light delivered from the drop signal output port

of each of the drop devices into an electrical signal.

27. An optical demultiplexer according to Claim 23, further comprising a transducer for converting the signal light delivered from the drop signal output port of each of the drop devices into an electrical signal.

28. An optical signal processing method comprising the steps of:  
branching a time-division multiplexed optical signal having a plurality of channels into a first optical signal and a second optical signal;  
10 introducing the first optical signal and the second optical signal to a non-linear waveguide such that the second optical signal is delayed a time corresponding to one channel from the first optical signal;  
changing a refractive index of the non-linear waveguide at first time, thereby changing phase of the optical signal in each channel passing the non-linear  
15 waveguide after the first time;  
introducing the first optical signal and the second optical signal, which are both outputted from the non-linear waveguide, to an interference separator such that the first optical signal is delayed a time corresponding to one channel from the second optical signal; and  
20 separating the optical signal in the channel, in which the first optical signal and the second optical signal are out of phase, among the corresponding channels of the first optical signal and the second optical signal.

29. A wavelength converting method comprising the steps of:  
25 branching a continuous light having a first wavelength into a first continuous light and a second continuous light;

introducing the first continuous light and the second continuous light to a non-linear waveguide;

changing a refractive index of the non-linear waveguide at first time by introducing, to the non-linear waveguide, a control light pulse having a second wavelength different from the first wavelength, thereby changing phases of the first continuous light and the second continuous light both passing the non-linear waveguide after the first time;

introducing the first continuous light and the second continuous light, which are both outputted from the non-linear waveguide, to an interference separator

such that the first continuous light is delayed a first delay time from the second continuous light; and

outputting an optical signal having the first wavelength only during a period in which the first continuous light and the second continuous light are out of phase.